

Application No. 10/732,957
Amendment dated October 26, 2004
Reply to Office Action of July 27, 2004

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1. (Currently Amended) A projection optical system for projecting an image displayed on a predetermined display surface onto a predetermined projection surface comprising:

a front lens unit situated on the projection surface side;

a rear lens unit situated on the display surface side;

a first decentering lens unit situated between the front lens unit and the rear lens unit, movable in a direction ~~vertical~~perpendicular to an optical axis of the projection optical system;

a second decentering lens unit situated between the front lens unit and the rear lens unit, movable in a direction ~~vertical~~perpendicular to an optical axis of the projection optical system and substantially ~~vertical~~perpendicular to a direction where the first decentering lens unit is moved; and

a driving mechanism for continuously reciprocating the first and second decentering lens units in directions ~~vertical~~perpendicular to the optical axis,

wherein the projected image on the projection surface is periodically shifted by reciprocating the first and second lens units, and

wherein the following conditions are fulfilled:

$$0.01 \leq |FR/FD1| \leq 0.2, \text{ and}$$

$$0.01 \leq |FR/FD2| \leq 0.2,$$

where FD1 represents a focal length of the first decentering lens unit, FD2 represents a focal length of the second decentering lens unit, and FR represents a focal length of the rear lens unit.

2. (Original) The projection optical system as claimed in claim 1, wherein the first decentering lens unit has positive optical power, and the second decentering lens unit has negative optical power.

3. (Original) The projection optical system as claimed in claim 2, wherein the first decentering lens unit is a plane-convex lens element, the second decentering lens unit is a plane-concave lens element, and curved surfaces thereof are opposed to each other.

4. (Original) The projection optical system as claimed in claim 1, further comprising an aperture stop situated between the front and rear lens units, and wherein the first and second decentering lens units are situated at the vicinity of the aperture stop.

5. (Original) The projection optical system as claimed in claim 1, wherein the projection optical system is a zoom optical system having a movable lens unit that is movable in a direction of the optical axis for zooming, the movable lens unit being included only in the front lens unit.

6. (Currently Amended) The projection optical system as claimed in claim 1, wherein the first and second decentering lens units are supported by lens frames, individually, and wherein the driving mechanism includes:

a supporter for supporting the lens frame so as to be rotatable; and

an actuator for rotating the lens ~~frame~~frame about the ~~supporter~~supporter in a plane perpendicular to the optical axis of the projection optical system, the actuator disposed substantially on the opposite side of the supporter with respect to a center of the decentering lens unit.

7. (Currently Amended) The projection optical system as claimed in claim 1, wherein the first and second lens units are supported by lens frames, individually, and wherein the driving mechanism includes:

a guide shaft for guiding a movement of the decentering lens unit, fitted in a through hole provided in the lens ~~frame~~frame;

an actuator for linearly reciprocating the lens frame along the guide shaft, disposed on the opposite side of the guide shaft with respect to a center of the decentering lens unit.

8. (Original) The projection optical system as claimed in claim 1, wherein the first and second decentering lens units and the driving mechanism are integrated into a single optical unit.

9. (Currently Amended) A projection optical system for projecting an image displayed on a predetermined display surface onto a predetermined projection surface comprising:

a first decentering lens unit movable in a direction ~~vertical~~perpendicular to an optical axis of the projection optical system;

a second decentering lens unit movable in a direction ~~vertical~~perpendicular to an optical axis of the projection optical system and substantially ~~vertical~~perpendicular to a direction where the first lens is moved; and

a driving mechanism for continuously reciprocating the first and second decentering lens units in directions ~~vertical~~perpendicular to the optical axis,

wherein the projected image on the projection surface is periodically shifted by reciprocating the first and second decentering lens unit, and

wherein a pair of the first and second decentering lens units is disposed on a most end part of the display side of the projection optical system and following conditions are fulfilled:

$$0.01 \leq |LB/FD1| \leq 0.2, \text{ and}$$

$$0.01 \leq |LB/FD2| \leq 0.2,$$

where FD1 represents a focal length of the first decentering lens unit, FD2 represents a focal length of the second decentering lens unit, and LB represents an air distance equivalent of a back focal distance of a part of the projection optical system except the first and second decentering lens units.

10. (Original) The projection optical system as claimed in claim 9, wherein the first decentering lens unit has positive optical power, and the second decentering lens unit has negative optical power.

11. (Original) The projection optical system as claimed in claim 10, wherein the first decentering lens unit is a plane-convex lens element, the second decentering lens unit is a plane-concave lens element, and curved surfaces thereof are opposed to each other.

12. (Original) The projection optical system as claimed in claim 9, wherein the projection optical system is a zoom optical system whose focal length is variable.

13. (Currently Amended) The projection optical system as claimed in claim 9, wherein the first and second decentering lens units are supported by lens frames, individually, and wherein the driving mechanism includes:

a supporter for supporting the lens frame so as to be rotatable; and

an actuator for rotating the lens ~~frame~~frame about the ~~supporter~~, supporter in a plane perpendicular to the optical axis of the projection optical system, the actuator disposed substantially on the opposite side of the supporter with respect to a center of the decentering lens unit.

14. (Currently Amended) The projection optical system as claimed in claim 9, wherein the first and second lens units are supported by lens frames, individually, and wherein the driving mechanism includes:

a guide shaft for guiding a movement of the decentering lens unit, fitted in a through hole provided in the lens ~~frame~~frame;

an actuator for linearly reciprocating the lens frame along the guide shaft, disposed on the opposite side of the guide shaft with respect to a center of the decentering lens unit.

15. (Original) The projection optical system as claimed in claim 9, wherein the first and second decentering lens units and the driving mechanism are integrated into a single optical unit.

16. (Currently Amended) An image projection apparatus for projecting an image displayed on a predetermined display surface onto a predetermined projection surface comprising:

~~a projection optical system as claimed in claim 1 or claim 9;~~

a front lens unit situated on the projection surface side;

a rear lens unit situated on the display surface side;

a first decentering lens unit situated between the front lens unit and the rear lens unit, movable in a direction perpendicular to an optical axis of the image projection apparatus;

a second decentering lens unit situated between the front lens unit and the rear lens unit, movable in a direction perpendicular to an optical axis of the projection optical system and substantially perpendicular to a direction where the first decentering lens unit is moved;

a driving mechanism for continuously reciprocating the first and second decentering lens units in directions perpendicular to the optical axis; and

a light valve situated on the display surface for displaying an image, having a plurality of pixels arranged with a predetermined pitch, each pixel displaying one point of the image,

wherein the projected image on the projection surface is periodically shifted by reciprocating the first and second lens units,

wherein the image displayed on pixels [[are]]is changed according to [[a]] positions of the first and second decentering lens units. ~~units, and~~

wherein the following conditions are fulfilled:

$$0.01 \leq |FR/FD1| \leq 0.2, \text{ and}$$

$$0.01 \leq |FR/FD2| \leq 0.2,$$

where FD1 represents a focal length of the first decentering lens unit, FD2 represents a focal length of the second decentering lens unit, and FR represents a focal length of the rear lens unit.

17. (Currently Amended) The ~~projection-optical-system~~ image projection apparatus as claimed in claim 16, wherein the first decentering lens unit has positive optical power, and the second decentering lens unit has negative optical power.

18. (Currently Amended) The ~~projection-optical-system~~ image projection apparatus as claimed in claim 17, wherein the first decentering lens unit is a plane-convex lens element, the second decentering lens unit is a plane-concave lens element, and curved surfaces thereof are opposed to each other.

19. (Currently Amended) The ~~projection-optical-system~~ image projection apparatus as claimed in claim 16, wherein the projection optical system is a zoom optical system whose focal length is variable.

20. (Currently Amended) The image projection apparatus as claimed in claim 16, wherein the pixel of the light valve is projected onto the projection surface by the projection optical system as an image element, and wherein movements of the first and second decentering lens units cause an image shift of 0.3 to 1 times of ~~[[an]]~~ a pitch of the image element in a projection image on the projection surface.

21. (Original) The image projection apparatus as claimed in claim 16, wherein a locus of an image shifting on the projection surface by movements of the first and second decentering lens units is a circle.

22. (Original) The image projection apparatus as claimed in claim 16, wherein a locus of an image shifting on the projection surface by movements of the first and second decentering lens units is a quadrangle.

23. (New) An image projection apparatus for projecting an image displayed on a predetermined display surface onto a predetermined projection surface comprising:

a first decentering lens unit movable in a direction perpendicular to an optical axis of the image projection apparatus;

a second decentering lens unit movable in a direction perpendicular to an optical axis of the projection optical system and substantially perpendicular to a direction where the first lens is moved;

a driving mechanism for continuously reciprocating the first and second decentering lens units in directions perpendicular to the optical axis; and

a light valve situated on the display surface for displaying an image, having a plurality of pixels arranged with a predetermined pitch, each pixel displaying one point of the image,

wherein the projected image on the projection surface is periodically shifted by reciprocating the first and second lens units,

wherein the image displayed on pixels are changed according to a positions of the first and second decentering lens units, and

wherein a pair of the first and second decentering lens units is disposed on a most end part of the display side of the projection optical system and following conditions are fulfilled:

$$0.01 \leq |FR/FD1| \leq 0.2, \text{ and}$$

$$0.01 \leq |FR/FD2| \leq 0.2,$$

where FD1 represents a focal length of the first decentering lens unit, FD2 represents a focal length of the second decentering lens unit, and FR represents a focal length of the rear lens unit.

24. (New) The image projection apparatus as claimed in claim 23, wherein the first decentering lens unit has positive optical power, and the second decentering lens unit has negative optical power.

25. (New) The image projection apparatus as claimed in claim 24, wherein the first decentering lens unit is a plane-convex lens element, the second decentering lens unit is a plane-concave lens element, and curved surfaces thereof are opposed to each other.

26. (New) The image projection apparatus as claimed in claim 23, wherein the projection optical system is a zoom optical system whose focal length is variable.

27. (New) The image projection apparatus as claimed in claim 23, wherein the pixel of the light valve is projected onto the projection surface by the projection optical system as an image element, and wherein movements of the first and second decentering lens units cause an image shift of 0.3 to 1 times of a pitch of the image element in a projection image on the projection surface.

28. (New) The image projection apparatus as claimed in claim 23, wherein a locus of an image shifting on the projection surface by movements of the first and second decentering lens units is a circle.

29. (New) The image projection apparatus as claimed in claim 23, wherein a locus of an image shifting on the projection surface by movements of the first and second decentering lens units is a quadrangle.

30. (New) A projection optical system for projecting an image displayed on a predetermined display surface onto a predetermined projection surface comprising:

a front lens unit situated on the projection surface side;

a rear lens unit situated on the display surface side;

a decentering lens unit situated between the front lens unit and the rear lens unit, movable in a direction perpendicular to an optical axis of the projection optical system; and

a driving mechanism for continuously reciprocating the decentering lens unit, wherein the projected image on the projection surface is periodically shifted by reciprocating the decentering lens unit, and

wherein the following condition is fulfilled:

$$0.01 \leq |FR/FD1| \leq 0.2$$

where FD1 represents a focal length of the decentering lens unit, and FR represents a focal length of the rear lens unit.

31. (New) A projection optical system for projecting an image displayed on a predetermined display surface onto a predetermined projection surface comprising:

a decentering lens unit movable in a direction perpendicular to an optical axis of the projection optical system, the decentering lens unit being disposed on a most end part of the display side of the projection optical system; and

a driving mechanism for continuously reciprocating the decentering lens unit, wherein the projected image on the projection surface is periodically shifted by reciprocating the decentering lens unit, and the following condition is fulfilled:

$$0.01 \leq |LB/FD1| \leq 0.2$$

where FD1 represents a focal length of the decentering lens unit, and

LB represents an air distance equivalent of a back focal distance of a part of the projection optical system except the decentering lens unit.

32. (New) The projection optical system as claimed in claim 30, further comprising an aperture stop situated between the front and rear lens units, and wherein the decentering lens unit is situated at the vicinity of the aperture stop.

33. (New) The projection optical system as claimed in claim 30, wherein the projection optical system is a zoom optical system having a movable lens unit that is movable in a direction of the optical axis for zooming, the movable lens unit being included only in the front lens unit.

34. (New) The projection optical system as claimed in claim 30, wherein the decentering lens unit is supported by a lens frame and wherein the driving mechanism includes:

a supporter for supporting the lens frame so as to be rotatable; and

an actuator for rotating the lens frame about the supporter in a plane perpendicular to the optical axis of the projection optical system, the actuator disposed substantially on the opposite side of the supporter with respect to a center of the decentering lens unit.

35. (New) The projection optical system as claimed in claim 30, wherein the lens unit is supported by a lens frame and wherein the driving mechanism includes:

a guide shaft for guiding a movement of the decentering lens unit, fitted in a through hole provided in the lens frame;

an actuator for linearly reciprocating the lens frame along the guide shaft, disposed on the opposite side of the guide shaft with respect to a center of the decentering lens unit.

36. (New) The projection optical system as claimed in claim 30, wherein the decentering lens unit and the driving mechanism are integrated into a single optical unit.

37. (New) The projection optical system as claimed in claim 31, wherein the projection optical system is a zoom optical system whose focal length is variable.

38. (New) The projection optical system as claimed in claim 31, wherein the decentering lens unit is supported by a lens frame and wherein the driving mechanism includes:

a supporter for supporting the lens frame so as to be rotatable; and

an actuator for rotating the lens frame about the supporter in a plane perpendicular to the optical axis of the projection optical system, the actuator disposed substantially on the opposite side of the supporter with respect to a center of the decentering lens unit.

39. (New) The projection optical system as claimed in claim 31, wherein the lens unit is supported by a lens frame and wherein the driving mechanism includes:

a guide shaft for guiding a movement of the decentering lens unit, fitted in a through hole provided in the lens frame;

an actuator for linearly reciprocating the lens frame along the guide shaft, disposed on the opposite side of the guide shaft with respect to a center of the decentering lens unit.

40. (New) The projection optical system as claimed in claim 31, wherein the decentering lens unit and the driving mechanism are integrated into a single optical unit.

41. (New) An image projection apparatus for projecting an image displayed on a predetermined display surface onto a predetermined projection surface comprising a projection optical system, the projection optical system including:

a front lens unit situated on the projection surface side;

a rear lens unit situated on the display surface side;

a decentering lens unit situated between the front lens unit and the rear lens unit, movable in a direction perpendicular to an optical axis of the projection optical system;

a driving mechanism for continuously reciprocating the decentering lens unit, and

a light valve situated on the display surface for displaying an image, having a plurality of pixels arranged with a predetermined pitch, each pixel displaying one point of the image,

wherein the projected image on the projection surface is periodically shifted by reciprocating the decentering lens unit, and

wherein the following condition is fulfilled:

$$0.01 \leq |FR/FD1| \leq 0.2$$

where FD1 represents a focal length of the decentering lens unit, and FR represents a focal length of the rear lens unit.

42. (New) The image projection apparatus as claimed in claim 41, wherein the projection optical system is a zoom optical system whose focal length is variable.

43. (New) The image projection apparatus as claimed in claim 41, wherein the pixel of the light valve is projected onto the projection surface by the projection optical system as an image element, and wherein movement of the decentering lens unit causes an image shift of 0.3 to 1 times of a pitch of the image element in a projection image on the projection surface.

44. (New) An image projection apparatus for projecting an image displayed on a predetermined display surface onto a predetermined projection surface comprising a projection optical system, the projection optical system including:

a decentering lens unit movable in a direction perpendicular to an optical axis of the projection optical system, the decentering lens unit being disposed on a most end part of the display side of the projection optical system;

a driving mechanism for continuously reciprocating the decentering lens unit, and

a light valve situated on the display surface for displaying an image, having a plurality of pixels arranged with a predetermined pitch, each pixel displaying one point of the image,

wherein the projected image on the projection surface is periodically shifted by reciprocating the decentering lens unit, and the following condition is fulfilled:

$$0.01 \leq |LB/FD1| \leq 0.2$$

where FD1 represents a focal length of the decentering lens unit, and

LB represents an air distance equivalent of a back focal distance of a part of the projection optical system except the decentering lens unit.

45. (New) The image projection apparatus as claimed in claim 44, wherein the projection optical system is a zoom optical system whose focal length is variable.

Application No. 10/732,957
Amendment dated October 26, 2004
Reply to Office Action of July 27, 2004

46. (New) The image projection apparatus as claimed in claim 44, wherein the pixel of the light valve is projected onto the projection surface by the projection optical system as an image element, and wherein movement of the decentering lens unit causes an image shift of 0.3 to 1 times of a pitch of the image element in a projection image on the projection surface.